

A Method for Removing Pacing Artifacts from Ultra-high-frequency Electrocardiograms

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Introduction: Cardiac resynchronization therapy (CRT) is an effective treatment for heart-failure patients with ventricular dyssynchrony. Analysis of ultra-high frequencies in ECG (UHFECG) has been shown to provide precise identification for the selection of CRT recipients, but the use of UHFECG for CRT optimization is limited due to the fact that UHFECG activity is buried under pacemaker stimuli. While removing the rising edge of a stimulus is quite straightforward, the localization and removal of the end of the post-stimulus recharge phase is more complicated due to its very low amplitude and interference with depolarization signals in QRS onset.

Method: 12-lead 5 kHz ECG during an 3–10 minute rest period was measured in 15 patients with an implanted biventricular pacemaker. We detected artifacts as 10-ms-long segments with high energy in frequencies of 800–1200 Hz. We have removed the area around detected peaks in the time domain by applying a linear function supplemented by a spline function on the edges. After artifact elimination, the amplitude envelopes of the QRS complex were computed in a frequency band of 500–1000 Hz and averaged with an R-wave trigger (UHFQRS).

Results: Detection of artifacts, the beginning of the rising edge of the stimulating pulse and the end of the recharge phase, was evaluated against manually annotated marks with sensitivity and specificity of 0.98 and 0.97. Although the proposed method can successfully eliminate pacemaker stimuli, a relatively large amount of the signal is lost (35 ± 13 ms on average). Suppressing the effect of the stimulator while maintaining a useful signal is a task for the future.

